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A Brazilian Free-tailed Bat, *Tadarida brasiliensis* (I. Geoffroy, 1824) (Chiroptera, Molossidae), colony in Santa Eulalia, Chihuahua, Mexico, with records of other bat species

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Abstract. We report here the first record of a colony of the Brazilian Free-tailed Bat, *Tadarida brasiliensis* (I. Geoffroy, 1824), in a mine located in central Chihuahua, Mexico. This record represents the most central point of the distribution of the species in the state and is located in the Central Valleys biome. We highlight the importance of recognizing and preserving this mine as a refuge for the largest bat colony reported in the state of Chihuahua.

Keywords. Central Valleys, Distribution, Nearctic, Northern Mexico

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Introduction

The Brazilian Free-tailed Bat, *Tadarida brasiliensis* (I. Geoffroy, 1824), is distributed from central United States to Argentina and Chile (Simmons 2005; Eger 2007). In Mexico, it is widely distributed throughout the country with the exception of the lowlands of the Yucatan Peninsula (Simmons 2005). This species has been recorded from sea level to 3,200 m a.s.l., although most of the records are located between 1,000 and 2,000 m. It occurs in several types of vegetation, including xerophilous scrub, tropical dry forests, and oak-pine forests, but always close to arid environments (Arita and Ortega 2005). In Chihuahua, *T. brasiliensis* has been recorded mostly in the northern and eastern part of the state (Anderson 1972), with a few scattered records from southern and western Chihuahua; there is an absence of records from the central part of the state.

Tadarida brasiliensis is a segregationist species, but it has been found sharing shelters with at least other six species (Arita 1993a, 1993b), such as *Eptesicus fuscus* (Palisot de Beauvois, 1796), *Mormoops megalophylla* (Peters, 1864), *Myotis velifer* (J.A. Allen, 1890), *Myotis austroriparius* (Rhoads, 1897), *Nycticeius humeralis* (Rafinesque, 1818), and *Corynorhinus rafinesquii* (Lesson, 1827). Roosts include caves, tree holes, mines, and buildings (Parera 2002). In the northern and southern parts of its distribution, *T. brasiliensis* forms maternity colonies (females, young, and only a few males) of up to 20 million individuals (McCracken 1984). In some places, researchers have reported densities of up to 1,800 adults/m^2 or 5,000 pups/m^2 (Davis et al. 1962; McCracken 1984, 1986). It feeds primarily on moths of potential agricultural importance (Wilkins 1989), and it is considered an important species for agriculture because it can control insect populations (Cleveland et al. 2006).

In the present work, we record the presence of a colony of *T. brasiliensis* in the central area of the state of

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Chihuahua, Mexico. Although there are previous records of this species from Chihuahua (Anderson 1972; Arroyo-Cabrales 1999; López-González and García Mendoza 2006), these are based mostly on individual specimens captured in the coniferous forests in the mountains of the Sierra Madre Occidental and in the intermountain canyons with tropical deciduous forest.

Methods

We visited and documented the colony of *Tadarida brasiliensis* on August 2018, and May 2019 in the "Santa Eulalia" mine located 3 km northeast of the town of Santa Eulalia, in the Municipality of Aquiles Serdán, 10 km southwest of Chihuahua City (Fig. 1). Most of the area surrounding the mine is privately owned (INEGI 2010). The mine is located within a private property called "Minas de Bustillos", where a mining concession extracts silver, lead, and zinc (Fig. 2). Aquiles Serdán is located in the middle of a compound of dry, arid hills surrounding the town. The mine has one internal, big cavern that leads to the deep parts of the mine where the bats live, and three big openings to the exterior. The main activities are mining and cattle grazing.

The region is characterized by two well-marked seasons, a warm period (spring and summer) and a cold one (autumn and winter). The climate is semi-arid, with temperatures between 40 °C and –14 °C. Annual rainfall averages 350 mm, with 60 days of rain. The town lies within the Chuviscar river basin; however, only during the rainy season are there small streams, such as the Santa Eulalia and other streams, with water (INEGI 2010).

The main vegetation is composed of xerophytic scrub and scrub mixed with various species of *Agave* L. and *Yucca* L. Observed vertebrates include (JAF pers. obs.) amphibians such as *Dryophytes arenicolor* (Cope, 1866), rattlesnakes of the genus *Crotalus* Linnaeus, 1758, species of birds belonging to the genera *Caprimulgus* Linnaeus, 1758, *Empidonax* Cabanis, 1855, *Buteo* Lacépede, 1799, and *Accipiter* Brisson, 1760, among others, and small rodents belonging to the genera *Neotoma* Say & Ord, 1825, *Peromyscus* Gloger, 1841, *Reithrodontomys* Giglioli, 1873, *Onychomys* Baird, 1857, and *Chaetodipus* Merriam, 1889.

To estimate the population size and species inhabiting the mine, we used the methodology proposed by Escalona-Segura et al. (2002), where the exit of the bats from the mine was photographed and recorded from 18:30 h until sunset. We used Nikon D3100 and 4K Sports Ultra cameras to do this. To estimate bat density, direct counts were made using a video camera without using visible light to minimize disturbance. The cameras were placed under the emergent path, pointing to the sky, each night of the recordings. Bat began exiting the mine at approximately 19:15 h, finishing around 20:00 h, and reaching a maximum density 12 min after the exiting began. The exits continued for about 70 min, extending past dusk. For each night, starting with the first bat to emerge and continuing until the bats are no longer distinguishable in the dark sky, one frame of video (240 frames/second) was extracted. Bat counts were extracted from the video frames using the "Find the Maxima" function and batch processing in ImageJ. It is important to mention that the rough estimation of numbers was achieved by using video analysis to obtain accurate counts of bats while light levels were sufficient, thus determining a baseline number and then extrapolating, using the images for all the chiropteran outputs. We also classify the roost based on the diversity and abundance of bats (Arita 1993a). To identify the bats using the mine we used mist nets, cameras, and ultrasonic detectors. Vespertilionid bats in the mine were distinguished from *T. brasiliensis* by having their tails included within the uropatagium. *Tadarida brasiliensis* has a free tail, which protrudes beyond the uropatagium (Wilkins 1989).

Additionally, three 12 m long nylon mist nets were placed: two at the main entrance of the mine, and one inside the mine on a small plain near the exit shaft). The capture and collection of specimens was carried out under the permit (SGPA / DGVS / 04283/17) issued by the Dirección General de Vida Silvestre SEMARNAT to one of us (ARM). The collected specimens were deposited in the Colección de Mamíferos de la Facultad de Zootecnia and Ecología, Universidad Autónoma de Chihuahua (UACH-CV). Likewise, Echo Meter Touch ultrasonic modules (WildLife Acoustics, Maynard, MA, USA) were used to detect and record the vocalizations of bats both inside and outside the mine.

Results

In the cave, the population size was estimated between 160,000 and 180,000 bats. Bats left the cave approximately at 19:15 h, finishing around 20:00 h, and reaching a maximum density 12 min after the start. Exiting continued for about 70 minutes after dusk. *Tadarida brasiliensis* was the most common species (26 specimens collected; Table 1), but the ultrasonic modules recorded another four species: *Myotis yumanensis* (H. Allen, 1864), *Antrozous pallidus* (Le Conte, 1856), *E. fuscus*, and *Lasiurus cinereus* (Palisot de Beauvois, 1796). Using mist nets, we captured 26 specimens of *T. brasiliensis*: 20 were males and six females; all specimens were adults, and sizes and weights were within the average reported for this species (Table 1).

Using the refuge classification based on the diversity and abundance of bats (Arita 1993a), this cave can be considered as a segregationist refuge, meaning a high individual abundance, but poor species richness.

Order Chiroptera
Family Molossidae

***Tadarida brasiliensis* (I. Geoffroy, 1824)**
Brazilian Free-tailed Bat
Figure 3

New records. MEXICO – Chihuahua • 26; Munici-

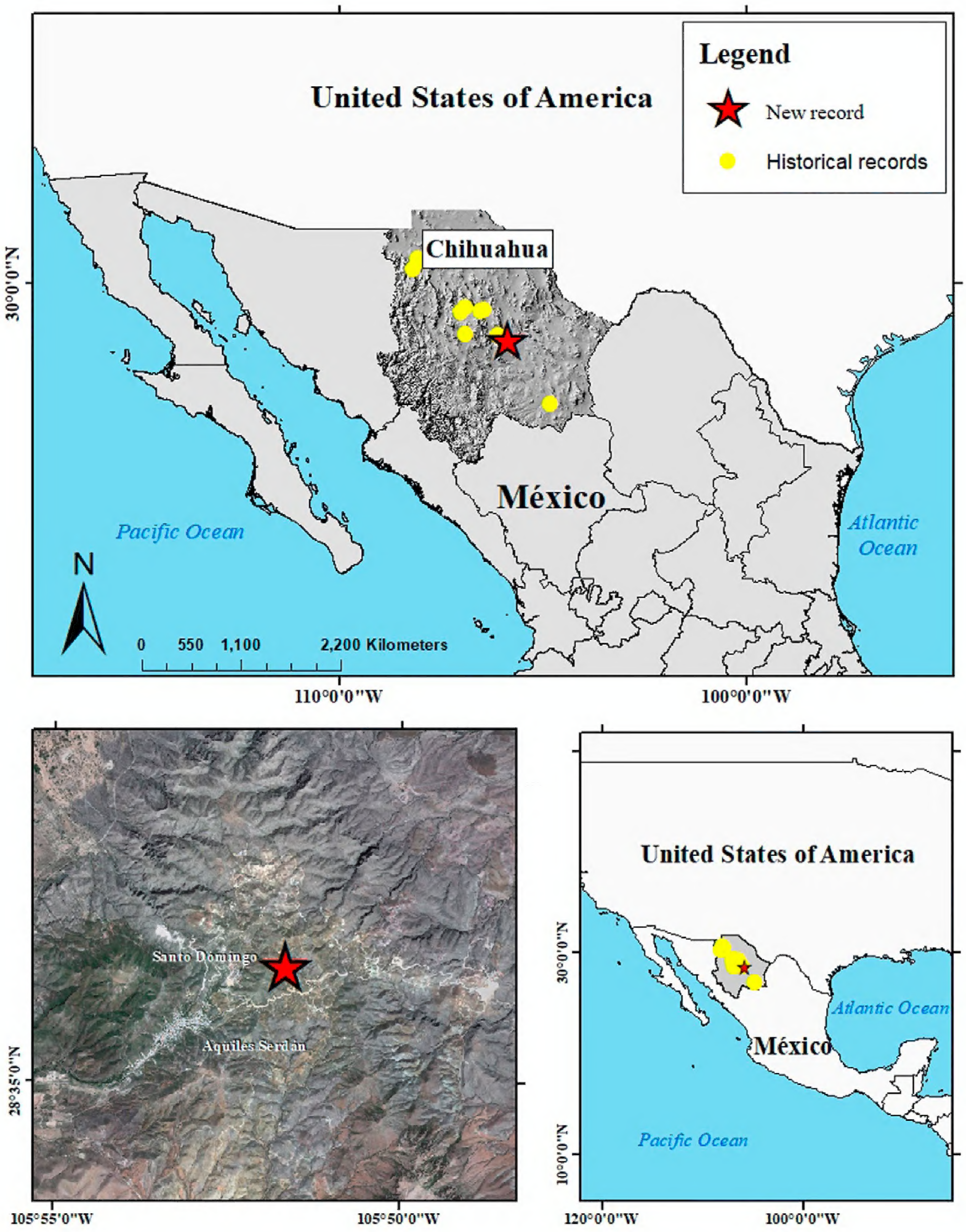

Figure 1. Geographic location of the Santa Eulalia Mine, Municipality of Aquiles Serdán, Chihuahua, Mexico, and the new and historical records of the Brazilian free-tailed bat (*Tadarida brasiliensis*) in central and northern Chihuahua.

pality of Aquiles Serdán; 28°36′28.7″N, 105°51′39.9″W; 1,697 m elev.; 15–18.VIII.2018 & 12–13.V. 2019; A. Rodríguez-Moreno, E.Y. Martínez-Hernández obs.; UACH-CV 455–481.

Identification. The specimens of *T. brasiliensis* were differentiated from other vespertilionid species in the area by their free tail, size (total length = 46–65 mm, tail length = 29–42 mm, hind foot length = 9–11 mm, ear length = 14–19, forearm length = 36–46 mm; Table 1); vertical groove on the upper lip; and ears not joined at

Figure 2. Santa Eulalia Mine, Municipality of Aquiles Serdán, Chihuahua.

the midline of the head (Arita and Ortega 2005).

Family Vespertilionidae

***Antrozous pallidus* (Le Conte, 1856)**
Pallid Bat

New records. MEXICO – Chihuahua • Municipality of Aquiles Serdán; 28°36′28.7″N, 105°51′39.9″W; 1,697 m elev.; 15–18.VIII.2018 & 12–13.V.2019; A. Rodríguez-Moreno, E.Y. Martínez-Hernández obs., acoustic records.

Identification. This bat is distinguished from the other species found in the mine by its larger size (total length: 92–135 mm), large eyes and ears with a long tragus, and a light coloration (Hermanson and O'Shea 1983). The calls were recorded outside the mine and are characterized by durations shorter than eight ms, 33 pulses of two sequences at a frequency of 81.0 kHz, and eight feeding buzzers were encountered along the survey. The pulses can be considered harmonics.

***Eptesicus fuscus* (Palisot de Beauvois, 1796)**
Big Brown Bat

New records. MEXICO – Chihuahua • Municipality of Aquiles Serdán; 28°36′28.7″N, 105°51′39.9″W; 1,697 m elev.; 15–18.VIII.2018 & 12–13.V.2019; A. Rodríguez-Moreno, E.Y. Martínez-Hernández obs., acoustic records.

Table 1. Meristic measurements and weight of the specimens of *Tadarida brasiliensis* captured in Santa Eulalia, Chihuahua, Mexico. All individuals were adult and reproductively inactive.

Collection no.	Sex	Total length (mm)	Tail length (mm)	Forearm length (mm)	Ear length (mm)	Foot length (mm)	Weight (g)
EU01	Female	83	31	45	13	9	20
EU02	Female	83	31	45	13	9	20
EU03	Male	83	31	45	13	9	20
EU04	Male	83	31	45	13	9	20
EU05	Female	83	31	45	13	9	20
EU06	Male	83	31	45	13	9	20
EU07	Female	83	31	45	13	9	20
EU08	Male	83	31	45	13	9	20
EU09	Male	83	31	45	13	9	20
EU10	Male	83	31	45	13	9	20
EU11	Male	83	31	45	13	9	20
EU12	Male	83	31	45	13	9	20
EU13	Male	83	31	45	13	9	20
EU14	Male	83	31	45	13	9	20
EU15	Male	88	30	41	12	10	20
EU16	Male	90	31	39	13	9	18
EU17	Male	91	28	45	13	8	20
EU18	Male	90	28	40	12	10	15
EU19	Male	95	31	42	13	8	13
EU20	Male	95	36	44	13	8	18
EU21	Female	93	31	45	14	9	17
EU22	Female	91	30	42	14	9	17
EU23	Male	91	32	44	13	8	16
EU24	Male	90	30	40	14	9	15
EU25	Male	90	30	42	12	8	14
EU26	Male	92	34	42	13	9	19

Figure 3. A *Tadarida brasiliensis* individual captured at the Santa Eulalia Mine, Municipality of Aquiles Serdán, Chihuahua, Mexico.

Identification. This species is easily distinguishable from other species found in the mine by its brown coloration and by a combination of a large and broad head, stocky body, and short and round ears and wings (Kurta and Baker 1990). It is an insectivorous bat usually emitting echolocation pulses distinguishable by the presence of two or three harmonics and a variation in the frequencies they emit according to their behavior. Its presence has been throughout North America where it uses caves, mines, and other refugees (Masters et al. 1991; Zamora-Gutiérrez et al. 2020). In the study area, the echolocation calls are characterized by durations shorter than 6 ms and bandwidths of approximately 16 kHz, and 87 pulses of 10 sequences at a frequency of 35 kHz; 20 feeding buzzers were recorded. The pulses can be considered harmonics.

***Lasiurus cinereus* (Palisot de Beauvois, 1796)**
North American Hoary Bat

New records. MEXICO – Chihuahua • Municipality of Aquiles Serdán; 28°36′28.7″N, 105°51′39.9″W; 1,697 m elev.; 15–18.VIII.2018 & 12–13.V.2019; A. Rodríguez-Moreno, E.Y. Martínez-Hernández obs., acoustic records.

Identification. This bat is characterized by a combination of a frosted pattern of dark brown, gray, and white fur, a large and furry interfemoral membrane, and its large size (total length = 134 mm; Shump and Shump 1982). This species has an echolocation pulse characterized by its low frequency compared to other bat species. *Lasiurus cinereus* has a wide distribution in America and moves between mountainous and temperate environments, including in the state of Chihuahua (Slought et al. 2014; López-González and García-Mendoza. 2006). The recorded echolocation calls (micro calls) are characterized by durations shorter than 8 ms and bandwidths of approximately 25 kHz, and 12 pulses of three sequences at a frequency of 30 kHz analyzed; 12 feeding buzzers were recorded.

***Myotis yumanensis* (H. Allen, 1864)**
Yuma Miotis

New records. MEXICO – Chihuahua • Municipality of Aquiles Serdán; 28°36′28.7″N, 105°51′39.9″W; 1,697 m elev.; 15–18.VIII.2018, 12–13.V.2019; A. Rodríguez-Moreno, E.Y. Martínez-Hernández obs., acoustic records.

Identification. This is a small bat with dark, dull pelage, large ears, and a total length of 84–99 mm (Braun et al. 2015). This species, like many bats of the genus *Myotis*, have echolocation pulses with high frequencies, and, particularly, this species has a minimum frequency of 50 Khz, although slight variations have been reported among individuals. Our recordings of calls from outside the mine are characterized by durations shorter than 9 ms, bandwidths of approximately 60 kHz, and 70 pulses of eight sequences at a frequency of 53 kHz. We recorded 13 feeding buzzers during our survey. No harmonics were observed in the sequences. This species has been recorded in several environments in northern Mexico (Weller et al. 2007; Zamora-Gutiérrez et al. 2020).

Discussion

The presence of a colony of *Tadarida brasiliensis* is important because of the population declines in some of the northernmost colonies of this species in the last 60 years. For example, Cockrum (1970) described severe reductions of up to 99% in Arizona's Eagle Creek Cave colony, from 25 million to 30,000 individuals in 1969. Furthermore, caves and mines are highly vulnerable ecosystems (Elliot 2000; Hamilton-Smith and Eberhard 2000), with the most common threats including urbanization, sinkhole development, groundwater contamination, and vandalism (Wilson 1985; Medellin 2003; Elliot 2004; Gunn 2004). In Mexico, some caves that in the 1950s and 1960s contained millions of individuals of *T. brasiliensis* have become tourist sites, were burned, or even dynamited, so that they no longer harbor bats (McCracken 1986).

Medellin et al. (2017) analyzed the importance, diversity, and ecosystem services of cave bats, with an emphasis on *T. brasiliensis*. They listed the refuges were cave bats have been reported in both Mexico and the United States, which total only 25 summer refuges and four winter shelters. The Santa Eulalia Mine described

here can be added to the known refuges for *T. brasiliensis* in northern Mexico and in the state of Chihuahua.

It is necessary to continue monitoring the mine to determine if *T. brasiliensis* is a year-round resident, or if its presence there is restricted to winter and it belongs to one of the two migratory groups described by Cockrum (1970), either migrating annually from Arizona and New Mexico south along the Sierra Madre Occidental, or migrating from Texas to Central Mexico along the Sierra Madre Oriental. It is also necessary to evaluate the population density of *T. brasiliensis* in Santa Eulalia minte using other techniques, such as those described by Betke et al. (2008) who used thermal imaging to determine the population densities in colonies of *T. brasiliensis*.

Within the area and influence of the Santa Eulalia colony (50–60 km) is the town of Delicias, Chihuahua, where the most crops are cotton for the production of vegetable oil and forage for dairy cattle, but other important crops include wheat, alfalfa, soybeans, sorghum, peanuts, corn, beans, chili, onion, and walnut (INEGI 2016). Bats from this colony are likely to move to these crops to feed on insects.

The conservation status of *T. brasiliensis* has not been assessed by the International Union for the Conservation of Nature or by the Mexican government. However, it is a migratory species included in Appendix I of the Convention on the Conservation of Migratory Species of Wild Animals (https://www.cms.int/en/species/tadarida-brasiliensis) and deserves to be protected. Although this species has not been assessed in any risk category, it is susceptible to human-mediated change. Our new data on the Santa Eulalia colony of *T. brasiliensis* is of importance for the conservation of this species, as it provides information on the distribution and abundance of this species in northern Mexico.

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Authors' Contributions

Conceptualization and visualization: JAF, ARM, EYMH. Formal analysis: ARM, EYMH. Funding acquisition: ARM. Investigation: EYMH. Validation: JAF. Writing – original draft: JAF. Writing – review and editing: JAF, ARM, EYMH.

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